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G2F
Selected US specifications from IPC sub-class G02F

(54) Liquid crystal lens having a variable focal length

(57) A liquid crystal lens having variable focal length includes a cell in which a liquid crystal (6) is confined. The magnitude of a voltage applied across the liquid crystal may be changed to control the focal length of the lens. The cell is defined by transparent plates (1, 2), at least part of which is formed of a photochromic material or a material which acts as a barrier to harmful rays. In this manner, the amount of transmitted light can be controlled reversibly in accordance with the amount of incident light so that harmful rays, such as ultraviolet rays, infrared rays or dazzling rays can be filtered out. The filter may comprise an acrylic resin with neodymium, or a separate liquid-crystal cell.

F I G. I

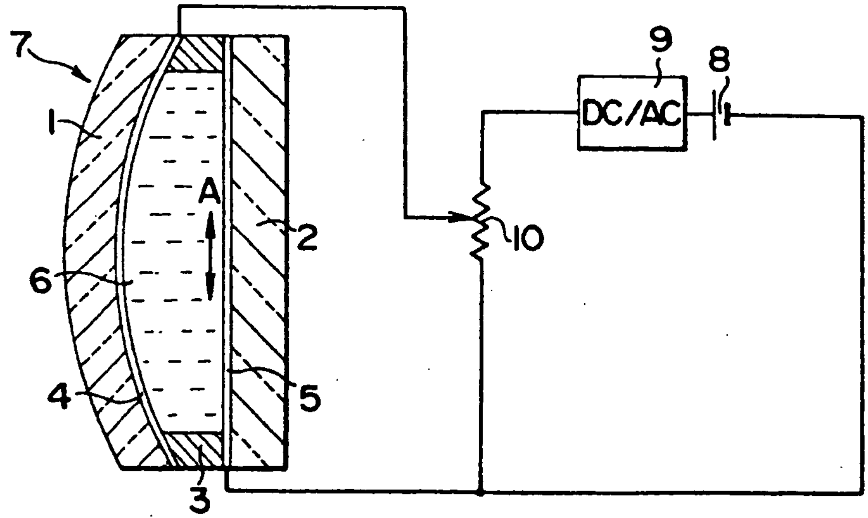

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FIG. 1

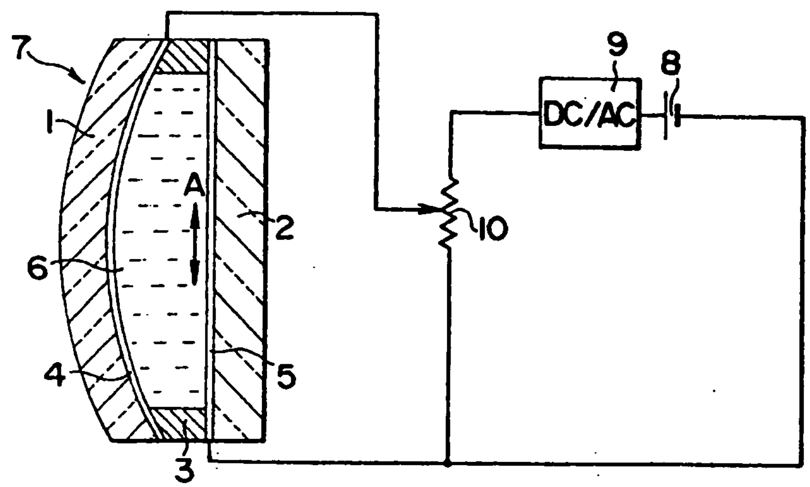
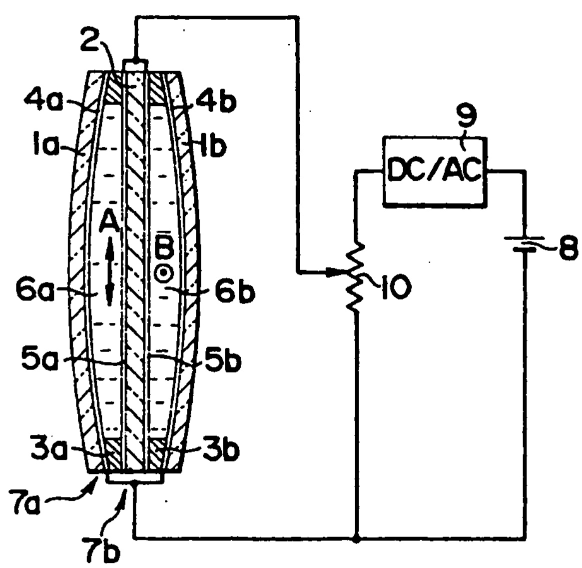

7
1
A
2
6
4
5
3
9
8
DC/AC
10

FIG. 2


2
4a
4b
1a
1b
A
B
6a
6b
5a
5b
3a
3b
7a
7b
9
DC/AC
8
10

2/3

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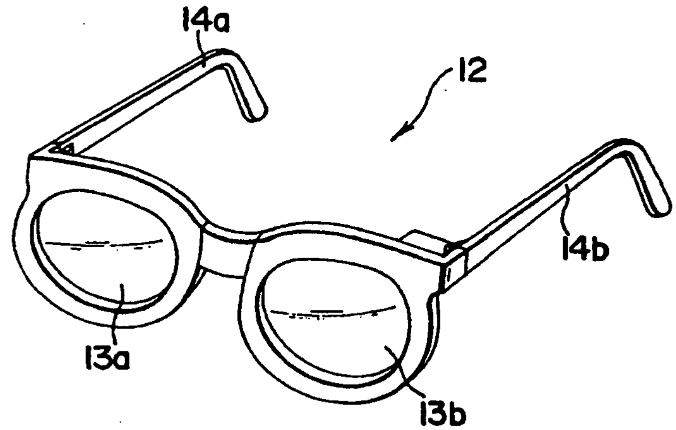
F I G. 3



F I G. 4

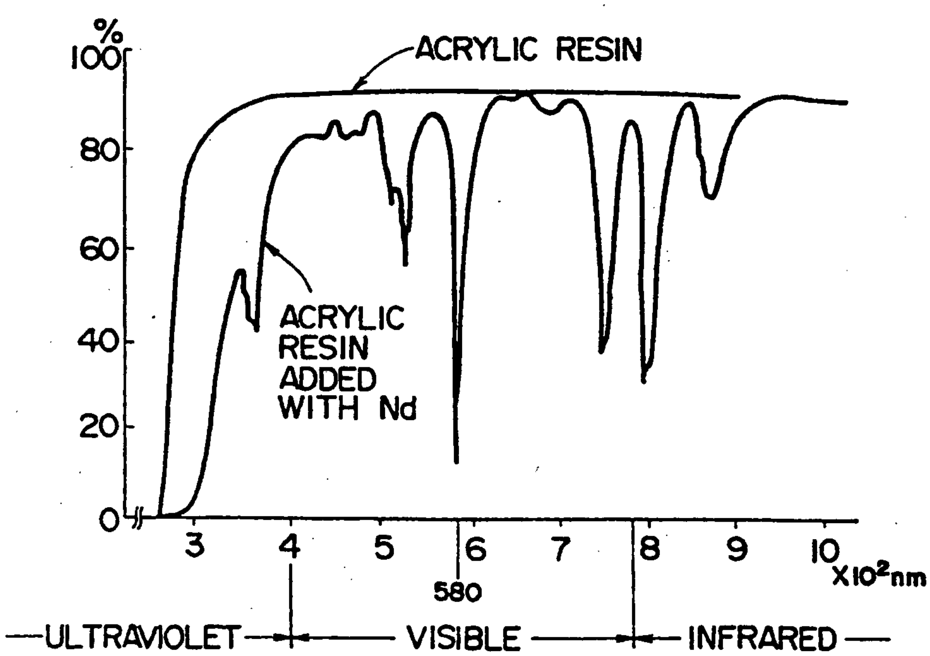


FIG. 5

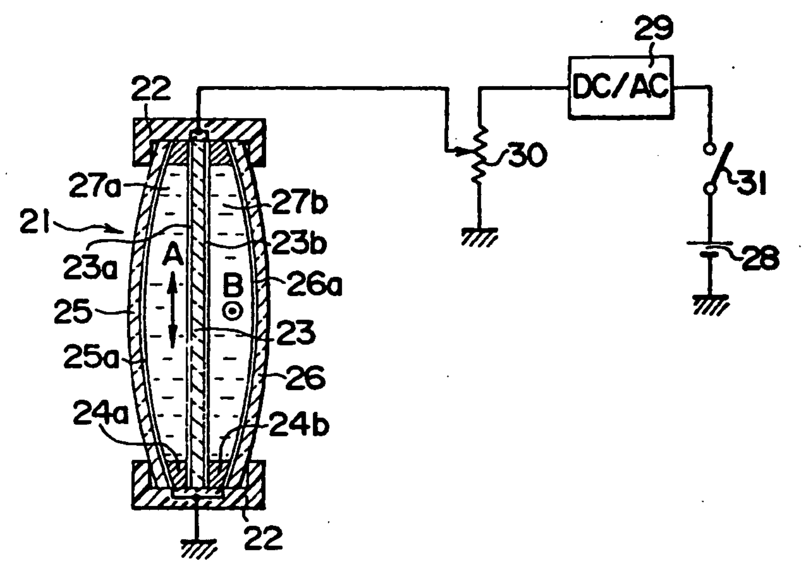
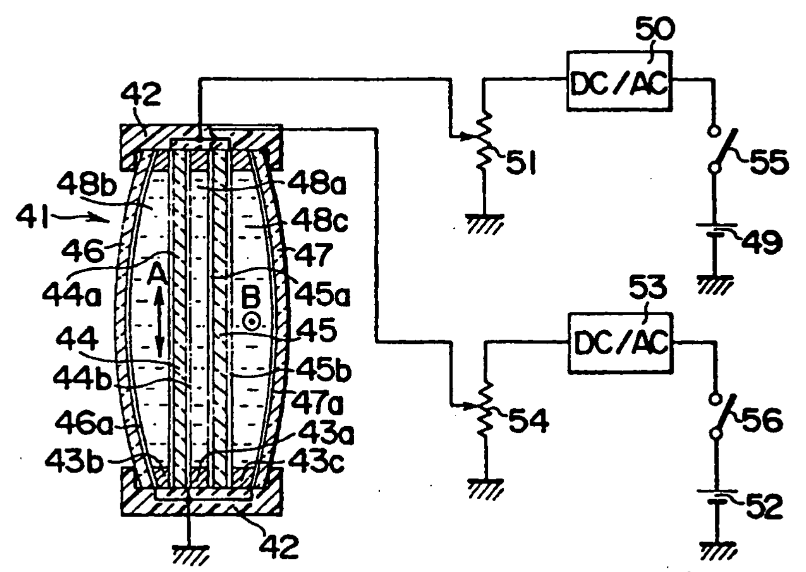

29
DC/AC
22
30
31
27a
27b
21
23b
23a
A
B
26a
28
25
23
25a
26
24a
24b
22

FIG. 6


50
DC/AC
42
51
55
48b
48a
41
48c
46
47
49
44a
A
B
45a
53
DC/AC
44
45
44b
45b
47a
54
56
46a
43a
43b
43c
52
42

SPECIFICATION

Liquid crystal lens having variable focal length

The invention relates to a liquid crystal lens having a variable focal length, and more particularly, to a liquid crystal lens including a hollow cell of lens configuration and defined by at least two transparent plates disposed in opposing relationship with each other and in which a liquid crystal is confined, allowing the focal length to be controlled in a variable manner by changing a voltage applied to the liquid crystal.

Recently, a variety of devices has been proposed which incorporate a liquid crystal lens having a variable focal length which is rendered possible by changing the optical properties of the liquid crystal in response to a change in the voltage applied. A liquid crystal exhibits a regular molecular orientation, which produces an anisotropy in its optical properties. It also exhibits an anisotropy in the dielectric constant which depends on the molecular structure. Consequently, by changing the magnitude of the voltage applied or the frequency of an alternating voltage applied, the orientation of molecules can be controlled. This allows the refractive index to be changed as light passes through the liquid crystal layer. By utilizing this effect, a liquid crystal cell may be formed which is configured in the shape of a lens, thus providing a lens having a variable focal length in accordance with a change in the refractive index.

By way of example, U.S.A. Patents No. 4,190,330 and No. 4,037,929 describe such liquid crystal lenses. A variable focus pair of spectacles which employs such liquid crystal lenses may be of great assistance to a patient who may have had his crystalline humor removed due to a cataract and hence suffers from a degradation in the ability to adjust the focal length of this eyes.

It will be noted that light of a high intensity or brightness will be an excessively strong stimulus to the eyes of those people who have weak eyes or who have had the crystalline humor removed due to a cataract, for example. In such instance, a pair of liquid crystal spectacles which is available in the prior art has a disadvantage that it cannot afford sufficient protection to the eyeballs from light of excessive intensity. While a liquid cyrstal lens permits the focal length to be changed in a convenient manner, it also exhibits a disadvantage in that a sufficient protection of the eyes against ultraviolet or infrared rays or other harmful or dazzling rays cannot be provided.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to provide a liquid crystal lens having variable focal length which is capable of protecting eyeballs against the incidence of an excessive amount of light.

According to one aspect of the present invention, a liquid crystal lens has a variable focal length and includes at least two transparent plates which are disposed in opposing relationship to each other to define a hollow lens-shaped cell in which a liquid crystal is confined, the transparent plates carrying on their inner surfaces, transparent electrodes across which a voltage is applied, the magnitude or the frequency of the voltage being changed to change the orientation of the molecules of the liquid crystal to thereby change the focal length of the lens, at least one part of the transparent plates being formed of a photochromic material having a transmission which reversibly changes in accordance with the amount of incident light.

It is another object of the invention to provide a liquid crystal lens having variable focal length which affords sufficient protection of the eyes against harmful rays.

According to another aspect of the present invention, a liquid crystal lens has a variable focal length and includes at least two transparent plates disposed in opposing relationship with each other to define a hollow lens-shaped cell in which a liquid crystal is confined, the transparent plates carrying on their inner surfaces, transparent electrodes cross which a voltage is applied, the magnitude or the frequency of the voltage being changed to change the orientation of the molecules of the liquid crystal to change the focal length of the lens, at least part of the transparent plate being formed of a material which acts as a barrier to harmful rays.

It is a further object of the invention to provide a liquid crystal lens having variable focal length which is capable of adjusting the transmission of light therethrough in accordance with the brightness of exterior light.

According to a further aspect of the invention, a liquid crystal lens has a variable focal length and includes at least two transparent plates disposed in opposing relationship to each other to define a hollow lens-shaped cell in which a liquid crystal is confined, the transparent plates carrying on their inner surfaces, transparent electrodes across which a voltage is applied, the magnitude or the frequency of the voltage being changed to change the orientation of the molecules of the liquid crystal to change the focal length of the lens, and means for controlling the amount of transmitted light in accordance with the intensity of incident light.

The invention allows the focal length of a liquid crystal lens to be changed in an electrical manner. A photochromic material or a material which intercepts or shields harmful rays is used to form at least part of a transparent plate which defines a cell for the liquid crystal lens. In this manner, in addition to the capabil-

ity of changing the focal length of the lens, the transmission of light can be reduced against incident light of an excessively high intensity in a reversible manner, or harmful rays can be shielded. Accordingly when it is used to construct a pair of spectacles, there is obtained a pair of spectacles which affords the combined functions of changing the focal length and protecting the eyes. The useful life of the liquid crystal lens can be increased by preventing or supressing a degradation in the properties of the liquid crystal which may result from photo-chemical reaction.

Also, the focal length can be changed continuously in accordance with the invention. In addition, in the event that extraneous light of excessively high intensity which may stimulate the eyes impinges, the transmission of light can be suppressed, thus preventing a stimulus from being applied to the eyes of a patient who has weak eyes, for example.

The invention is further described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a schematic cross section, to an enlarged scale, of a liquid crystal lens having variable focal length according to a first embodiment of the invention;

Figure 2 is a schematic cross section, to an enlarged scale, of a liquid crystal lens having variable focal length according to a second embodiment of the invention;

Figure 3 is a perspective view of a pair of spectacles which is formed by using the liquid crystal lenses shown in Fig. 2;

Figure 4 graphically shows the spectral transmission of a material used in the invention to shield harmful rays;

Figure 5 is a schematic cross section, to an enlarged scale, of a liquid crystal lens having variable focal length according to a third embodiment of the invention; and

Figure 6 is a schematic cross section, to an enlarged scale, of a liquid crystal lens having variable focal length according to a fourth embodiment of the invention.

Referring to Fig. 1, there is shown a liquid crystal lens according to a first embodiment of the invention. Specifically, a transparent plate 1 which is configured to exhibit a curvature/conforming to a lens and a flat transparent plate 2 are formed of a glass or plastics material in which photochromic material is dispersed. The two transparent plates 1, 2 are bonded together with a spacer 3 interposed therebetween to define a cell having a hollow interior and configured as a plano-convex lens. The inner surfaces of the plates 1, 2, which face each other, are coated with transparent electrodes 4, 5 in the form of thin films, which may be formed of indium oxide or tin oxide. The cell is filled with liquid crystal 6, thus forming a liquid crystal lens 7.

By applying a suitable treatment of the inner surface of the transparent plate 1, it is possible to achieve an orientation of the molecules of the liquid crystal which is parallel to the surface of the plate 1, as indicated by an arrow A. An alternating voltage may be applied across the liquid crystal 6. Specifically, a d.c. voltage from a battery 8 is converted by means of a DC/AC converter 9 into an alternating voltage, which is then applied through a variable resistor 10 across the pair of electrodes 4, 5.

When a linearly polarized wave which is polarized in a direction parallel to the direction A, which is also parallel to the direction of orientation of the molecules of the liquid crystal in the lens 7, impinges upon the lens 7, the orientation of molecule of the liquid crystal can be controlled to thereby change the focal length continuously by changing the magnitude of the voltage applied across the liquid crystal 6. Due to the material used, the transparent plates 1, 2 exhibit photochromic response. That is to say, the absorption spectrum of the material varies reversibly upon irradiation with light.

Photochromic glass which is extensively used in light modulating eyeglasses comprises silicate glass having a dispersion of silver halide therein. Upon irradiation with light, the silver halide is decomposed to produce metal silver. The metal silver which is formed by decomposition condenses within the glass to form colloidal silver on the order of 40 Å to make the glass to appear gray, thus reducing the transmission. A halogen gas which is produced simultaneously is confined within the glass. Upon interruption of the irradiation with light, the thermal diffusion causes the two to be recombined to extinguish the color, whereby it returns to a transparent glass.

By way of example, a chemical reaction of silver bromide (AgBr) occurs as follows:

$$AgBr \underset{\text{heat}}{\overset{\text{light}}{\rightleftharpoons}} Ag\ (\text{colloidal silver}) + 1/2\ Br_2$$

Since the transparent plates 1 and 2 are formed of a material which exhibits the photochromic response, when light having a high intensity impinges upon the liquid crystal lens 7, the two plates 1, 2 become colored, reducing the transmission. Accordingly, when this lens is used to form an eyeglass (in this instance, it is desirable to use it in combination with a polarizing plate), a protection of the eyeballs of a user is afforded. Such eyeglass can be very effectively utilized by a person who suffers from a degraded capability of adjusting the pupils. In the event incident light of high intensity impinges, any degradation in the liquid crystal due to photochemical changes can be prevented or suppressed. It will be appreciated that when the intensity of incident light reduces, the liquid crystal lens 7 returns to its original or transparent condition with a

recovered transmission of light. Thus, the described embodiment accommodates for both bright and dark instances.

To accomplish the second object of the invention, at least part of the transparent plates which define the cell is formed by a material which shields harmful rays. Specifically, the curved plate 1 and the flat plate 2, both shown in Fig. 1, are formed of a material which shields harmful rays, and are bonded together with the spacer 3 interposed therebetween to form a plano-convex lens cell.

The material which is used to shield harmful rays will now be considered. Harmful rays which must be shielded refer to those rays which have adverse influences upon the eyes of men, including ultraviolet ray, dazzling rays having a high luminosity, for example, having wavelengths around 580 nm and infrared rays, either alone or in combination. For example, ultraviolet rays and rays having wavelengths around 580 nm should br shielded in summer on the seashore when the sunshine has a high intensity. Rays of wavelengths around 580 nm should be shielded alone when viewing a CRT display indoors. Rays of wavelengths around 580 nm as well as infrared rays should be shielded when a user operates in a high temperature environment which causes the emission of infrared rays.

It is known that compounds of neodymium exhibits an absorption of light of a wavelength of 580 nm. For this reason, this material is attracting attention recently in the optical field to provide anti-dazzling property. It is possible to shield rays of wavelengths around 580 nm by means of a high polymer synthesis of neodymium with acrylic resin which is optically transparent.

Fig. 4 graphically shows the spectral transmission of an acrylic resin and of another acrylic resin which includes about 10% high polymer synthesis of neodymium. It will be noted that the acrylic resin including the high polymer synthesis of neodymium exhibits an absorption peak around 580 nm, and also includes improved ultraviolet and infrared shielding response as compared with the genuine acrylic resin. Accordingly, when the acrylic resin including the high polymer synthesis of neodymium is used to construct the transparent plates 1, 2, it will be seen that light of wavelengths around 580 nm as well as ultraviolet and infrared rays can be shielded. To provide a more perfect shielding effect of ultraviolet and infrared rays, a material which shields ultraviolet and infrared rays may be deposited on the surface of the neodymium added acrylic resin as by vacuum deposition to form a thin film thereof. When it is desired to shield the ultraviolet rays alone, a material which shields the ultraviolet ray may be deposited as a thin film, as by vacuum deposition, on the surface of the acrylic resin. Similarly, when it is desired to shield the infrared rays alone, a material which shields the infrared rays may be deposited as a thin film. In this manner, by a suitable choice of light shielding material depending on the intended use, harmful rays can be efficiently shielded.

Accordingly, when a liquid crystal lens having transparent plates 1, 2 which are formed of a material which shields harmful rays is used to construct a pair of spectacles, (in this instance, it is desirable to use a polarizing plate in combination), there is obtained a spectacle lens which permits an adjustment of the focal length and which protects the eyes from harmful rays contained in the incident light including ultraviolet rays, dazzling rays and infrared rays. It is also to be noted that the harmful rays mentioned above act to degrade the properties of the liquid crystal as a result of photo-chemical reaction, and hence the use of such material is also effective in preventing or suppressing a degradation in the liquid crystal material.

A second embodiment of the invention will now be described with reference to Fig. 2. In this embodiment, the transparent plate 2 used in the liquid crystal lens of the first embodiment is used in common for a pair of cells located on the opposite sides thereof. Each cell has a liquid crystal 6a, 6b which exhibits an identical characteristic confined therein, thus integrally forming a pair of liquid crystal lenses 7a, 7b. The liquid crystal lens 7a is constructed in the same manner as the liquid crystal lens 7 of the first embodiment. By contrast, the liquid crystal lens 7b is treated so that the molecules of the liquid crystal 6b has an orientation as indicated by a symbol B which is perpendicular to the plane of the drawing.

Thus, in the second embodiment, the liquid crystal lenses 7a, 7b are disposed in overlying relationship with each other so that the directions of orientation of their liquid crystal molecules are perpendicular to each other. In this manner, the combination can be operated as a variable focal length lens with respect to natural light without requiring the use of a polarizing plate in combination therewith. In this embodiment, each of the transparent plates 1a, 2 and 1b is formed of a photochromic material as in the first embodiment, and hence the transmission reduces in response to the incidence of an excessively intense light. Where the transparent plates 1a, 2 and 1b are formed of a material which shields harmful rays, the incidence of ultraviolet rays, dazzling rays and infrared ray can be intercepted.

The second embodiment described above may be used as lenses 13a, 13b of spectacles 12 shown in Fig. 3. In this manner, there is obtained a spectacle lens which functions as a focussing lens or auxiliary lens and which also protects the eyes of a user against excessively intense light or harmful rays. In the arrangement of Fig. 3, DC/AC converter 9

and battery 8 may be contained inside the arms 14a, 14b of the spectacles, thus providing a pair of spectacles which is of aesthetically acceptacle appearance.

The configuration of the transparent plates 1, 1a, 1b, 2 which define a cell in which liquid crystal 6, 6a, or 6b is confined is not limited to those described above, but they may assume a configuration which achieves a desired refractive power or focal length depending on the intended use of the liquid crystal lenses 7, 7a, 7b. By way of example, the transparent plates 1, 2 of the first embodiment may be both curved, plano-convex or plano-concave configuration as well. To improve the speed of response with which the orientation of the liquid crystal molecules changes in response to a voltage applied, either one or both of surfaces may be formed as a Fresnel lens surface while reducing the thickness of the liquid crystal layer. The use of a Fresnel surface permits a thin and light weight construction to be achieved, which is preferred to improve the appearance of the spectacles. In addition, the Fresnel surface may be saw-toothed or triangular in cross section to improve the speed of response of the liquid crystal.

In the described embodiments, the transparent plates 1, 1a, 1b and 2 have been described as formed by a material having a photochromic response or a material which shields the harmful rays. However, it is not essential that such plate be entirely formed of either material. For example, in the second embodiment, the transparent plates 1a, 1b located on the opposite outer sides may be formed of a photochromic material or a harmful ray shielding material while the inner plate 2 may be formed of a transparent glass or a transparent plastics material. Alternatively, only one of the transparent plates 1 or 1a which is located on the incidence side of light may be formed of a photochromic material or harmful ray shielding material. As a further alternative, all of the transparent plates 1, 1a, 1b, 2 may be formed of an ordinary transparent glass while at least one of the outer transparent plates (1, 2 in Fig. 1 or 1a, 1b in Fig. 2) may be coated by a thin film of a harmful ray shielding material or photochromic material. Finally, a transparent plate may be locally formed of a photochromic material or a harmful ray shielding material. In this instance the surface of the transparent plate may be partly coated with a photochromic material or a harmful ray shielding material.

For use with a person who has experienced a surgery of his eye, or eyes at least one or part of the transparent plates 1, 1a, 1b, 2 may be formed by a colored material as used in a sunglass to prevent the operated area from being viewed through the spectacle lens.

In the describe embodiments, the magnitude of the applied voltage has been changed to change the focal length. However, the invention is not limited thereto, but the frequency of the voltage applied thereto may be changed to control the refractive index or the focal length. such control may be exercised by the application of a magnetic field.

The liquid crystal lens of the invention can be effectively used in spectacles as described above, but it should be understood that the application of the invention is not limited thereto, and that the invention is equally applicable to a variety of optical instruments in which the incidence of an excessive amount of light or harmful rays is undesirable. To give an example, the invention may be used as part of a focussing optical system which is used to take a picture. The use of the invention in such application results in a favorable optical camera system since the amount of incident light is automatically controlled.

As is well recognized, the refractive index of most liquid crystals generally changes with temperature. Accordingly, as disclosed in Japanese Patent Application No. 183,087/1984 and UK Patent Application No. 8521564, a sensor may be provided to detect the temperature of the liquid crystal and to provide an output signal which can be utilized to maintain the refractive index substantially unchanged.

The third object of the invention initially mentioned can be achieved by liquid crystal lenses shown in Figs. 5 and 6. Specifically, Fig. 5 shows a third embodiment of the invention in which a liquid crystal lens 21 having variable focal length is secured to a frame 22 and forms a liquid crystal spectacle lens. The lens 21 comprises a common transparent plate 23, and a pair of transparent plates 25, 26 which may be convex to the outside, for example, and which are bonded to the plate 23 with spacers 24a, 24b interposed therebetween. Liquid crystals 27a, 27b are confined in cells defined between the plates 25, 26, respectively, and the common plate 23. It is to be understood that the liquid crystal 27a is treated so that the orientation of the molecules thereof are directed in a direction parallel to the plane of the drawing while the liquid crystal 27b is treated so that the optical orientation of the molecules is directed perpendicular to plane of the drawing. Plates 23, 25, 26 are formed by colored material such as colored glass which permits visibility therethrough. The opposite surfaces of the transparent plate 23 are coated by thin films of transparent electrodes 23a, 23b while the inner surfaces of the transparent plates 25, 26 are coated by thin films of transparent electrodes 25a, 26a. The transparent electrodes 25a, 26a are connected to earth while the transparent electrodes 23a, 23b are connected together and connected to a tap on a variable resistor 30 which is connected between the output of DC/AC converter 29 and earth. The

converter is fed from a d.c. source 28 through a switch 31. The output voltage from the converter 29 as divided by the variable resistor 30 is applied across the liquid crystals 27a, 27b to vary the orientation of their molecules, thereby controllably changing the focal length. It is to be noted that the colored member may be used with at least one of the transparent plates 23, 25, 26. The transparent member may comprise a transparent glass in which colored material is dispersed or a coating of a colored material on the glass surface.

With the liquid crystal lens 21 having variable focal length as described above, the focal length of the lens 21 can be changed continuously by changing the magnitude of a voltage appplied across the liquid crystals 27a, 27b to control the orientations of the molecules of the liquid crystal. In addition, by forming at least one of the transparent plates 23, 25 and 26 with a colored member, the incidence of intense light which may stimulate the eyes can be alleviated. The use of a colored member can advantageously prevent a degradation in the characteristic of the liquid crystal. In this manner, it is possible to provide a liquid crystal lens having variable focal length which also functions as a sunglass, by merely using a colored material for one of the transparent plates which define the lens.

Fig. 6 shows a liquid crystal lens having variable focal length according to a fourth embodiment of the invention. A liquid crystal lens 41 is shown as comprising a pair of common transparent plates 44, 45 which are fixed in position relative to each other with a spacer 43a interposed therebetween and which are also secured to an eyeglass frame 42, and a pair of outer transparent plates 46, 47 of a convex configuration, for example, which are disposed on the opposite sides of and bonded to the common transparent plates 44, 45, respectively, with spacers 43b, 43c interposed therebetween. Liquid crystals 48b, 48c are confined in the spacers defined between the transparent plates 44 and 46 and between the transparent plates 45, 47. It is to be understood that the liquid crystal 48b is treated so that their molecules have an orientation which is parallel to the plane of the drawing while the liquid crystal 48c is treated so that their molecules have an orientation perpendicular to the plane of the drawing. It will be appreciated that the liquid crystals 48b, 48c serve changing the refractive index. A liquid crystal 48a is confined in the space defined between the transparent plates 44, 45 for controlling the transmission. It will be noted that transparent electrodes 44a, 44b in the form of thin films are formed on the opposite surfaces of the transparent plate 44 while transparent electrodes 45a, 45b in the form of thin films are formed on the opposite surfaces of the transparent plate 45. Transparent electrodes 46a, 47a in the form of thin films are also formed on the inner surfaces of the transparent plates 46, 47. The transparent electrodes 46a, 47a and 44c are connected together and connected to earth. The transparent electrodes 44a, 45b are connected together and connected to a tap on a variable resistor 51 which is in turn connected to the output of DC/AC converter 50 which is in turn fed from a d.c. source 49 through a switch 55. The transparent electrode 45a is connected to a tap on a variable resistor 54 which is connected to the output of DC/AC converter 53 which is in turn fed from a d.c. source 52 through a switch 56.

In the arrangement of Fig. 6, the output voltage of the converter 50 as divided by the variable resistor 51 is applied across the liquid crystals 48b, 48c in order to control the orientation of the molecules of the liquid crystals which are primarily used to control the refractive index, thus allowing the focal length to be changed in a continuous manner. The output voltage of the converter 53 as divided by the variable resistor 54 is applied across the liquid crystal 48a to control the orientation of the molecules of the liquid crystal 48a which is primarily used to control the transmission, thus allowing the transmission of light to be adjusted continuously. Accordingly, in a situation where extraneous light is intense enough to stimulate the eyes, the variable resistor 54 may be adjusted to control the transmission exhibited by the liquid crystal 48.

While the focal length and the transmission are changed by changing the magnitude of applied voltages in this embodiment, a similar effect can be achieved by changing the frequency of the applied voltages.

CLAIMS

1. A liquid crystal lens having a variable focal length and including at least two transparent plates which are disposed in opposing relationship to each other to define a hollow lens-shaped cell in which a liquid crystal is confined, the transparent plates carrying on their inner surfaces, transparent electrodes across which a voltage is applied, the magnitude or the frequency of the voltage being changed to change the orientation of the molecules of the liquid crystal to thereby change the focal length of the lens, at least part of the transparent plates being formed of a photochromic material having a transmission which reversibly changes in accordance with the amount of incident light.

2. A liquid crystal lens according to Claim 1, in which the photochromic material comprises photochromic glass formed by silicate glass in which a silver halide is dispersed.

3. A liquid crystal lens having a variable focal length and including at least two transparent plates disposed in opposing relationship with each other to define a hollow lens-shaped cell in which a liquid crystal is co-

nfined, the transparent plates carrying on their inner surfaces, transparent electrodes across which a voltage is applied, the magnitude or the frequency of the voltage being changed to change the orientation of the molecules of the liquid crystal to change the focal length of the lens, at least part of the transparent plate being formed of a material which acts as a barrier to harmful rays.

4. A liquid crystal lens according to Claim 3, in which the material which acts as a barrier to harmful rays comprises a material which acts as a barrier to ultraviolet rays.

5. A liquid crystal lens according to Claim 4, in which the material which acts as a barrier to ultraviolet rays comprises a transparent acrylic resin having a high polymer synthesis of neodymium.

6. A liquid crystal lens according to Claim 3, in which the material which acts as a barrier to harmful rays comprises an anti-dazzling material.

7. A liquid crystal lens according to Claim 6, in which the anti-dazzling material comprises a transparent acrylic resin having a high polymer synthesis of neodymium.

8. A liquid crystal lens according to Claim 3, in which the material which acts as a barrier to harmful rays comprises a material which acts as a barrier to infrared rays.

9. A liquid crystal lens according to Claim 8, in which the material which acts as a barrier to infrared rays comprises a transparent acrylic resin having a high polymer synthesis of neodymium.

10. A liquid crystal lens having a variable focal length and including at least two transparent plates disposed in opposing relationship to each other to define a hollow lens-shaped cell in which a liquid crystal is confined, the transport plates carrying on their inner surfaces transparent electrodes across which a voltage is applied, the magnitude or the frequency of the voltage being changed to change the orientation of the molecules of the liquid crystal to change the focal length of the lens, and means for controlling the amount of transmitted light in accordance with the intensity of incident light.

11. A liquid crystal lens according to Claim 10, in which the means for controlling the amount of transmitted light comprises at least one of the transparent plates which is formed of a colored member which permits vision therethrough.

12. A liquid crystal lens according to Clain 11, in which the colored member comprises a transparent colored glass.

13. A liquid crystal lens according to Claim 10, in which the means for controlling the amount of transmitted light comprises a body of liquid crystal which is interposed between the transparent plates and which has a controllable transmission.

14. A liquid crystal lens according to Claim 13, in which the body of liquid crystal is capable of adjusting continuously the amount of transmitted light by changing the magnitude or the frequency of a voltage which is applied thereto externally.

15. A liquid crystal lens, constructed and adapted to operate substantially as herein described with reference to and as illustrated in the accompanying drawings.

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